Migration Policies and Takeover Times in Genetic Algorithms

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A specification of a parallel genetic algorithm (GA) with multiple populations includes the size and number of the populations (demes), the topology of the connections between the demes, the migration rate, and the policy to select emigrants and to replace existing individuals with incoming migrants. The objective of this paper is to study how the migration policy affects the speed of convergence.

The choices of migrants and the replacement of individuals are not often considered important parameters of parallel GAs. However, these choices affect considerably the speed of convergence, which is important because excessively slow or fast convergence may cause the GA to fail. The results of this study also offer an explanation to claims of superlinear speedups on parallel GAs. A plausible cause for these claims may be that the *total* amount of work in the parallel GA is less than the work that a serial GA requires to reach the same solution. But what causes the reduction in the work? The paper argues that some migration policies increase the selection pressure and cause the parallel GA to converge faster than would be expected from dividing a large population into smaller demes.

The individuals that emigrate may be selected at random, or among the best individuals in a deme. Similarly, migrants may replace random individuals at the receiving deme, or they may replace the worst individuals. The full version of the paper (Cantú-Paz, 1999) presents difference equations that predict the proportion of good individuals in a deme for the four possible migration policies. The equations assume that migration occurs every generation. Figure 1 presents plots of the difference equations along with experimental results (two demes with 1000 individuals, pairwise tournament selection, no crossover, and no mutation). The proportion of migrants is $m = 10\%$. The growth of good individuals is significantly faster when good individuals are chosen to migrate, regardless of how they replace individuals.

The takeover time is the number of generations that it takes a single individual of the best class to get $n-1$ copies in a population of size n. Figure 2 shows the takeover times in demes with 10000 individuals and pairwise tournament selection. The plots illustrate that the convergence is faster with higher migration rates, and that the fastest convergence occurs when good migrants replace bad individuals, which is the most frequently-used migration policy.

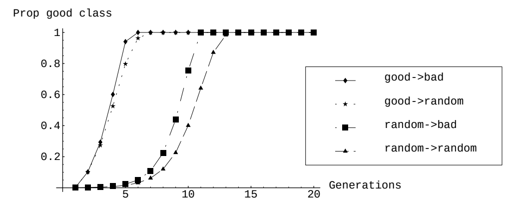

Figure 1: Comparison of the growth of the good individuals using different migration policies.

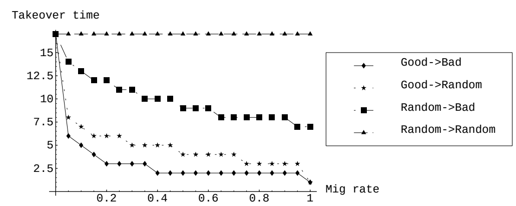

Figure 2: Takeover times using different migration policies and varying the migration rate.

The shortened convergence times are certainly desirable, but also constitute a potential source of failure. If the search fails, the user may switch to a less aggressive migration policy or reduce the migration rate.

References

Cantú-Paz, E. (1999) *Migration policies and takeover times in parallel genetic algorithms.* IlliGAL Technical Report No. 99008. University of Illinois at Urbana-Champaign. (www-illigal.ge.uiuc.edu)